# Raman Chemical Imaging of Explosive-Contaminated Fingerprints for Forensic Attribution

The ability to detect trace quantities of explosives has become increasingly important in recent years due to several high profile terrorist attacks around the world, as well as the prevalence of improvised explosive device (IED) attacks in Iraq and Afghanistan. Raman spectroscopy is a particularly attractive detection technique because it is non-destructive, requires no sample preparation, and gives a high degree of chemical specificity. The non-destructive nature is particularly valuable in forensic applications, which allows for the identification of explosives without compromising the sample for further biometric analysis. If visual images of the fingerprint can be obtained without modifying the sample (e.g., enhancing the image by using cyanoacrylate fuming), then identification of the person who handled the explosive could also be obtained non-destructively.

Raman spectroscopy of explosives has received significant attention due to the need for new detection methods for these materials. Many Raman spectroscopy studies of explosives use red or near-infrared excitation (for example, 785 nm or 1064 nm), which minimize the spectral interference from fluorescence. UV excitation has also been used to perform Raman spectroscopy of explosives. This wavelength region has larger cross sections, which can enhance the signal intensity if the excitation wavelength is near that of an electronic transition. In addition, excitation wavelengths shorter than 250 nm spectrally separate fluorescence emission from the Raman scattered light.
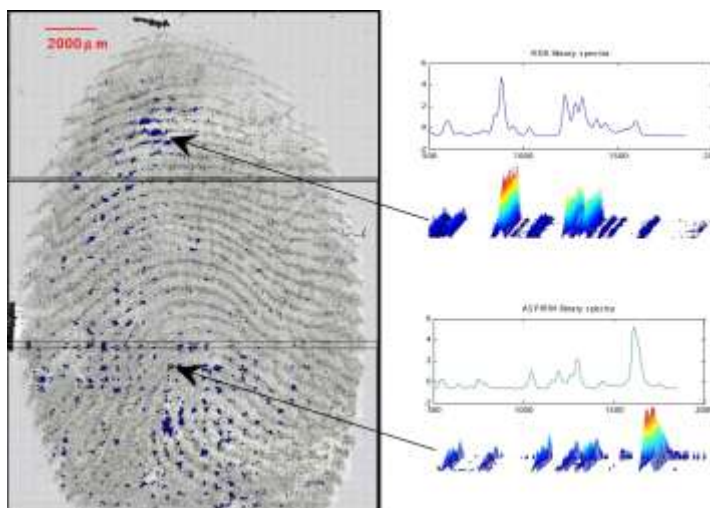


**Fingerprint (left) containing a mixture of trace explosive materials, as identified by Raman spectroscopy (right).**

The Edgewood Chemical Biological Center, in collaboration with the U.S. Army Criminal Investigation Laboratory, has demonstrated that Raman Chemical Imaging (RCI) can be used to collect a biometrically relevant image and spatially identify trace amounts of explosives of fingerprints. First, a montage of a bright-field and/or fluorescence images is obtained by taking a series of magnified images of the fingerprint. From this montage, a proprietary algorithm ranks potential regions that contain particulate material. These regions are examined using RCI to determine if explosives are present. Pearson's cosine cross-correlation technique is used to determine the spatial distribution of the explosives present. We have demonstrated detection of trace amounts of exogenous explosive material on strongly Raman scattering surfaces using an automated background subtraction algorithm. The explosive RDX was detected on polystyrene, polycarbonate, and painted white car panels. The procedures were also successfully used to detect PETN, HMX, ammonium and sodium nitrate, PETN, and RDX on black and silver car panels.

These measurements show that it is possible to detect traces of explosives on realistic surfaces encountered in everyday situations. Future work is directed towards reducing imaging process time and automating targeting of regions of interest. Miniaturizing and ruggedizing RCI systems by instrument manufacturers for improved field portability is another future goal of the project. Ultimately, with sufficient advances, these techniques could be used on scene for forensic analysis.

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